
A New Genus of Podostemaceae from Venezuela

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ABSTRACT. The new genus *Autana* C. T. Philbrick and species *A. andersonii* C. T. Philbrick are illustrated and described. The new species is documented from four rivers that drain into the Orinoco River, Amazonas, Venezuela. *Autana* is distinguished by three characters that do not occur in other Neotropical Podostemaceae. The upper surface of the flattened stem has an anastomosing pattern that is derived from a continuation of leaf margins. When the capsule is mature, the pedicel apex (and receptacle) is swollen and hollow. After anthesis, locations where the deciduous stamens attached become darkened and shaped like an inverted teardrop. Phylogenetic analyses indicate *A. andersonii* is sister to a clade containing species of *Castelnavia* Tul. & Wedd., *Oserya* Tul. & Wedd., *Noveloa* C. T. Philbrick, and *Rhyncholacis* Tul., as well as upright stemmed species of *Apinagia* Tul., and Central American and Mexican species of *Marathrum* Bonpl.

RESUMEN. Se ilustran y describen un género *Autana* C. T. Philbrick y una especie *A. andersonii* C. T. Philbrick nuevos. La especie nueva se registra de cuatro ríos que desembocan en el río Orinoco, Amazonas, Venezuela. *Autana* se distingue de otras Podostemaceae por tres caracteres que no se encuentran en ninguna de las otras especies de Podostemaceae neotropicales. La superficie superior del tallo aplanado tiene una figura anostomosada que surge de una continuidad de los márgenes de la hoja. Cuando la cápsula se madura, el ápice del pedicelo (y receptáculo) se hincha y se torna hueco. Los sitios donde los estambres caedizos estaban unidos, se oscurecen y toman la forma de una lágrima invertida. Los análisis filogenéticos indican que *A. andersonii*

es hermana de un clado que contiene especies de *Castelnavia* Tul. & Wedd., *Oserya* Tul. & Wedd., *Noveloa* C. T. Philbrick y *Rhyncholacis* Tul., así como de especies con tallos erguidos de *Apinagia* Tul. y de especies centroamericanas y mexicanas de *Marathrum* Bonpl.

Key words: Amazonas, aquatic plants, *Autana*, IUCN Red List, Podostemaceae, Venezuela.

Venezuela exhibits a rich diversity of Podostemaceae. Velásquez (1994) recognized eight genera and 22 species in the country. Philbrick et al. (2010) listed the same genera, but somewhat more (28) species. Berry (2004) reported 26 species for the Venezuelan Guayana alone. Six of the genera documented from Venezuela (*Apinagia* Tul., *Jenmaniella* Engl., *Marathrum* Bonpl., *Mourera* Aubl., *Oserya* Tul. & Wedd., *Rhyncholacis* Tul.) represent the subfamily Podostemoideae, while two otherwise occur in the Weddellenoideae (*Weddellina* Tul.) or Tristichoideae (*Tristicha* Thouars) (Royen, 1951, 1953, 1954). The current contribution adds an additional genus to Venezuelan Podostemaceae.

While conducting field studies along tributaries of the Orinoco River (Venezuela, Amazonas), specimens were collected that did not correspond to any of the presently recognized species or genera in the Podostemaceae. The new taxa described here belong to the Podostemoideae based on the presence of a spathella surrounding the flower, a 2-carpellate ovary, two stigmas, and distichous leaves. Molecular studies (ITS, *rbcL*, *trnL*) of Neotropical Podostemaceae indicate that the new species is distinct from all other taxa in subfamily Podostemoideae (Tippery et al., 2011, listed as “*Autana*,” see below). Conse-

quently it is placed into a newly recognized monotypic genus.

In the description for the new species, descriptive ranges are given as (minimum) median (maximum). Collection localities were analyzed in ArcMap 9.3 (ESRI, 2009), and river systems were mapped using geospatial rivers data from The Americas Base Map (Bletter et al., 2004). Specimen data coordinates were assumed to be in the World Geographic System (WGS) 1984. The extent of occurrence (EOO), a criterion used for IUCN Red List analysis (IUCN, 2009) to measure the area of a minimum convex polygon drawn around a set of occurrences, was calculated with Hawth's Tools Minimum Convex Polygon tool (Beyer, 2004), in the South America Albers Equal Area Conic coordinate system.

Autana andersonii C. T. Philbrick, gen. et sp. nov.

TYPE: Venezuela, Amazonas: Río Autana, 4.7660°N, 67.4567°W, 60 m, 5 Jan. 2006, C. T. Philbrick, A. Novelo R. & C. Lasso 5862 (holotype, VEN; isotypes, CAR, MO, WCSU). Figure 1.

Genus novum *Apinagiae* Tul. simile, sed ab ea caulibus applanatis supra cristulis anastomosantibus e foliorum marginibus oriundis instructis, apicibus pedicellorum inflatis cavisque et staminum caducorum ad receptaculum locis insertionis fuscatis obovoideisque differt.

Aquatic herbs, presumed perennial, attached to rocks in river rapids and waterfalls; roots not seen; stems prostrate or upright, the flattened stems repeatedly dichotomously or subdichotomously branched, (4–)12(–39) × (1.5–)4(–15) mm, with anastomosing pattern on upper surface derived from fused petiole margins, anastomosing pattern darkened and obscured as stem dries; the upright stems oval to slightly flattened. Leaves marginal on stems, to 3 m long, distichous, ditheous, bipinnately compound, circinate, petiolate; petioles (1.8–)9.8(–36.8) cm, oval to flattened when young, oval to terete at maturity, gradually tapering apically; petiole margins with membranous stipules when young, quickly falling, margins of adjacent leaf petioles fused, forming darkened, slightly raised ridges that form an anastomosing pattern on the stem; each pinna with 3 or 4 pinnules; petiolules (2–)15.5(–82) mm; pinnae at base of leaf (1.5–)5.5(–25.6) mm long, near middle of leaf (0.5–)4.3(–21.1) mm, near apex of leaf (0.5–)2.4(–11) mm; ultimate leaf divisions terete, (0.1–)0.6(–2.6) mm × (20–)60(–140) μm, arising alternately along central axis or dichotomously-subdichotomously divided. Flowers numerous, marginal or submarginal on the flattened stems, arising solitary in pockets between

leaf bases, hermaphroditic, actinomorphic, oriented vertically, pedicellate; pedicels in pre-anthesal flowers (1.2–)5.2(–22) mm long; covered by saclike spathe-lae, the spathella (3.6–)7.6(–12) × (1.1–)1.8(–2) mm, clavate, smooth, rupturing apically or subapically into 2 to 5 segments as pedicels elongate during anthesis. Tepals (5 to)7(to 9), (0.6–)2.1(–2.9) mm, arising between stamen filaments, linear, acute. Stamens in complete whorl around ovary, (5 to)7(to 9), anthers triangular, (0.7–)1.7(–2.2) × (0.3–)0.5(–0.7) mm at base, introrse, the thecae apices fused; filaments flattened to oval in cross section, attaching to anther in a pocket-like area, widest at base, (0.5–)1.8(–2.4) mm in post-anthesal flowers; pollen tricolpate, polar axis (15–)19(–22) μm wide; ovaries (1.2–)2.2(–2.6) × (0.6–)1.3(–1.9) mm, globose, with a medial longitudinal line from base to apex; stigmas 2, (0.1–)0.4(–0.9) mm, linear, widest at base, fused for most of length, distinct apically for < 0.2 mm, falling after anthesis. Capsules (1.3–)3(–4.1) × (1.1–)1.4(–1.9) mm, slightly flattened perpendicular to suture margin, valves 2, persistent, each with 5 non-suture ribs, suture margins also riblike, pedicellate; pedicels (0.4–)3.9(–5.8) cm × (0.6–)1.1(–1.4) mm, hollow at maturity, apex (receptacle) swollen and hollow, swollen portion extending (1.2–)4(–8) mm down pedicel, inverted teardrop-shaped recessed marks (or holes) where stamen filaments attached on swollen pedicel apex (0.2–)0.6(–1) × (0.1–)0.2(–0.3) mm; seeds (53 to) 103(to 169) per capsule, (0.2–)0.3(–0.4) × (0.1–)0.2(–0.3) mm, orange to brown, obovate.

Etymology. The genus name is taken from the Autana River, Amazonas, Venezuela, where the species was first collected (cf. Art. 20.1, McNeill et al., 2006). The specific epithet is in honor of Gregory J. Anderson (1944–), University of Connecticut, who played a central role in the professional development of the first author.

Distribution and IUCN Red List category. *Autana andersonii* is known from four rivers that drain into the Orinoco River (Fig. 2). The species is common where it occurs. The extent of occurrence (IUCN, 2009) of the species is estimated at 5400 km². The species is categorized as Vulnerable (VUA1cB1), using the IUCN Red List criteria (IUCN, 2009). Factors that make species of Podostemaceae particularly vulnerable to human impacts are discussed in Philbrick et al. (2010).

Additional observations. The genus level classification of much of Neotropical Podostemaceae remains questionable (e.g., Royen, 1951; Berry, 2004; Tippery et al., 2011). Phylogenetic analyses have revealed that

some presently recognized genera do not reflect natural evolutionary groups, i.e., are not monophyletic (reviewed in Tippery et al., 2011). Tippery et al. (2011), in their study of molecular and morphological characters, have shown that one strongly supported clade includes all sampled species from three genera (*Jenmaniella*, *Lophogyne* Tul., *Monostylis* Tul.), but only a subset of species from two others (*Apinagia*, *Marathrum*). This well-supported clade lacks apparent morphological synapomorphies.

Discussion. Tippery et al. (2011) reported that *Autana* aligned sister to a clade composed of a portion of the genera *Apinagia* and *Marathrum*, as well as species of *Oserya*, the newly recognized *Noveloa* C. T. Philbrick, *Castelnavia* Tul. & Wedd., and *Rhyncholacis* (see Tippery et al., 2011, for details). Moreover, *Autana* was not placed with species in other genera, i.e., with species of *Apinagia* and *Marathrum* not included in the large clade listed above, nor with *Jenmaniella*, *Monostylis*, *Lophogyne*, *Mourera*, and *Podostemum* Michx. Consequently, the species is placed in its own monotypic genus.

Several morphological characters are distinctive for *Autana andersonii*. The flattened prostrate stem has a unique anastomose pattern on the upper surface (Fig. 1A, B). This stem pattern is comprised of darkened, slightly raised ridges that represent extensions of the fused petiole margins of adjacent leaves. When the plant dies after being exposed by lowering water levels, the entire stem darkens and the anastomosing pattern can then be obscured. Three features associated with reproductive structures are also distinct. One relates to the stigmas; the others pertain to the fertile pedicels. All species of Neotropical Podostemaceae subfam. Podostemoideae (e.g., species of *Apinagia*, *Jenmaniella*, *Macarenia* P. Royen, *Marathrum*, *Oserya*, *Rhyncholacis*) have two stigmas. For most species, the stigmas are free for the majority of their length, fused only at the base. In contrast, the two stigmas of *A. andersonii* are fused for most of their length, with only a short segment (< 0.2 mm) free at the apex.

The pedicel of most Podostemoideae elongates during anthesis, thus resulting in the mature capsule projecting well past the ruptured spathella, e.g., species of *Apinagia*, *Marathrum*, and *Rhyncholacis*. In contrast, the capsule of species of *Castelnavia* and *Cipoia* C. T. Philbrick, Novelo & Irgang remains inside the ruptured spathella, as the pedicel does not elongate (e.g., Philbrick et al., 2009). *Autana andersonii* possesses an elongated pedicel when in fruit.

Features of the mature pedicel apex (receptacle) are distinctive for *Autana andersonii*. Hollow pedicel

apices, when capsules are mature, are common in Neotropical Podostemaceae (e.g., *Autana*, *Apinagia*, *Jenmaniella*, *Marathrum*, *Monostylis*, *Rhyncholacis*). In most genera, the pedicel apex gradually expands apically, or is barely expanded at all. In contrast, the mature pedicel apex of *A. andersonii* and some species of *Marathrum* (e.g., *M. utile* Tul.) and *Rhyncholacis* (e.g., *R. penicillata* Matthiesen) is abruptly expanded. When this occurs in *Marathrum* and *Rhyncholacis*, the expanded pedicel apex is cup-shaped (concave). In contrast, *A. andersonii* has an expanded pedicel apex that convexly develops and is obovate in outline when viewed laterally. Moreover, the demarcation between the expanded pedicel apex and the capsule base is distinguished by a narrowed region (Fig. 1I, J).

The location where stamen filaments attach is a conspicuous feature on the expanded pedicel apex of *Autana*. In *A. andersonii* the stamen filaments fall away soon after anthesis, which is common in Podostemaceae. The location where a stamen had attached to the pedicel, however, develops into a recessed darkened area shaped like an inverted teardrop (widest apically, narrowed basally) (Fig. 1I, J). These areas are distinctive, and as the capsule matures they often break down and form holes; one can see into the inflated hollow pedicel apex via these holes. The capsules often persist for several months (or between seasons) and the holes in the pedicels become prominent. Consequently, such features associated with the mature capsules (expanded, hollow pedicel apex with holes) are a reliable way to identify *A. andersonii* long after the plant has died back after being exposed by lowering water levels.

The stem orientation of *Autana andersonii* is incompletely known. Collections of the species that included living material (i.e., the type Philbrick et al. 5862 and paratypes Philbrick et al. 5860 and 5861) possessed stems attached to the substratum throughout their ventral surfaces; they were prostrate. Three paratype collections (Philbrick et al. 5875, 5863, and 6318), however, possessed some stems that may have had a single basal attachment point to the substratum, and these stems could be either upright or pendant. The three latter collections were comprised of dried stems, and mature capsules that had been exposed by lowering water levels.

Paratypes. VENEZUELA. **Amazonas:** Río Autana, 4.8022°N, 67.4861°W, 60 m, 4 Jan. 2006, Philbrick, Novelo & Lasso 5860, 5861 (CAR, MO, VEN, WCSU); Río Sipapo, 4.8155°N, 67.7293°W, 6 Jan. 2006, Philbrick, Novelo & Lasso 5863 (CAR, MO, VEN, WCSU); Río Cuao, Raudal del Dante, 5.0442°N, 67.5605°W, 6 Jan. 2006, Philbrick, Novelo & Lasso 5867 (CAR, MO, VEN, WCSU); Río Cuao, Raudal del Dante, 5.0442°N, 67.5605°W, 17

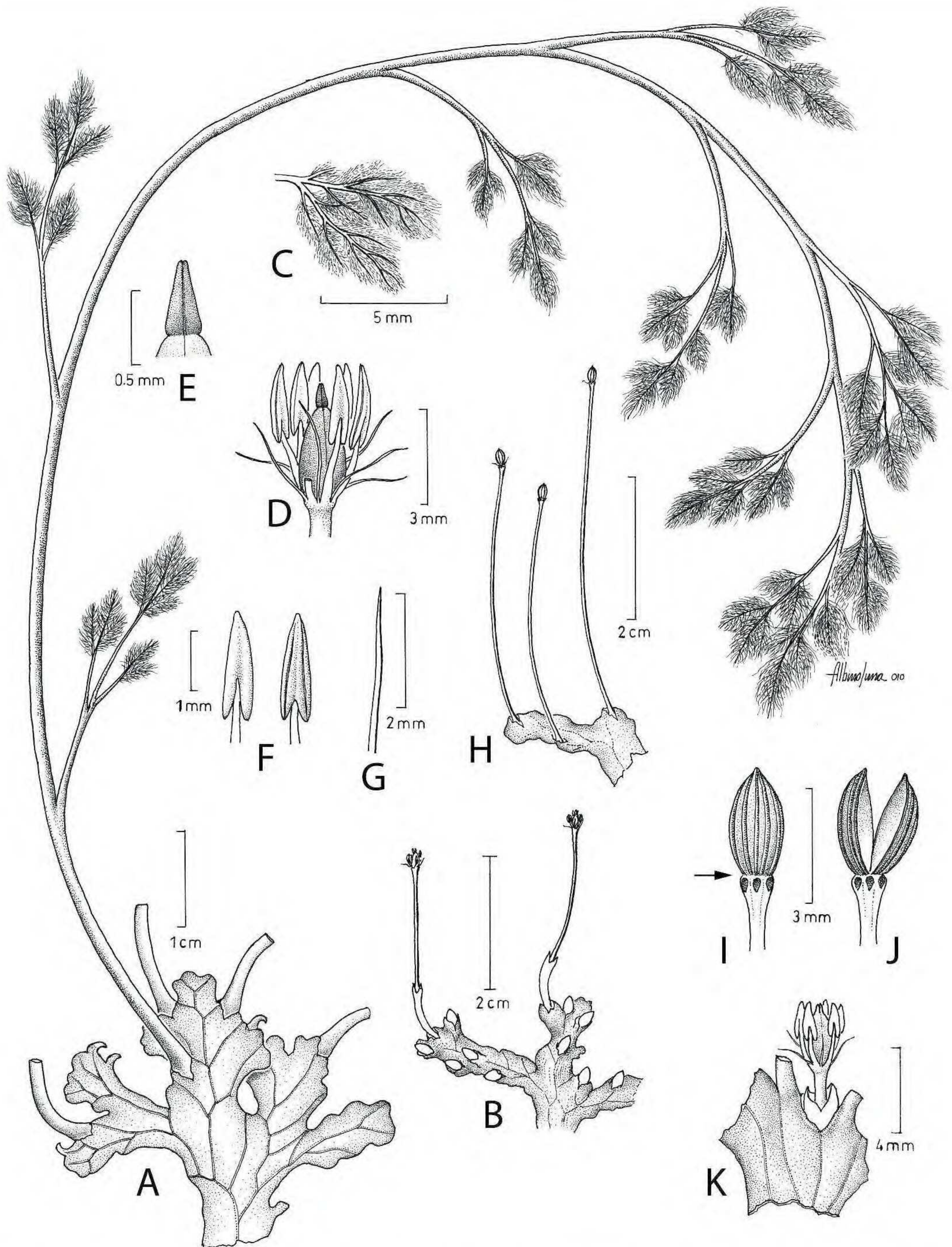


Figure 1. Vegetative and reproductive features of *Autana andersonii* C. T. Philbrick. —A. Portion of branched, flattened, prostrate stem viewed from above with four leaf bases and one complete pinnately compound leaf. Note anastomosing pattern on stem. The entire leaf illustrates the prominent petiole, the acropetally shortened internodes, with most pinnae having three pinnules. —B. Constricted portion of branched, flattened, prostrate stem after drying. Twelve flowers are shown, with two ruptured through the spathella and projected on prominent pedicels. Ten flowers remain enclosed within intact spathellae. —C. Detail of segment of pinnule showing dichotomously to subdichotomously divided penultimate divisions. —D. Open flower showing apical portion of pedicel, six stamens, six tepals, and the ovary and erect stigmas that are laterally fused for most of their length. One stamen has been removed. —E. Detail of the two fused, rigid stigmas. —F. Proximal (right) and distal (left) views of stamen showing apex of filament and two thecae fused apically. A linear zone of introrse dehiscence is seen proximally, at right.

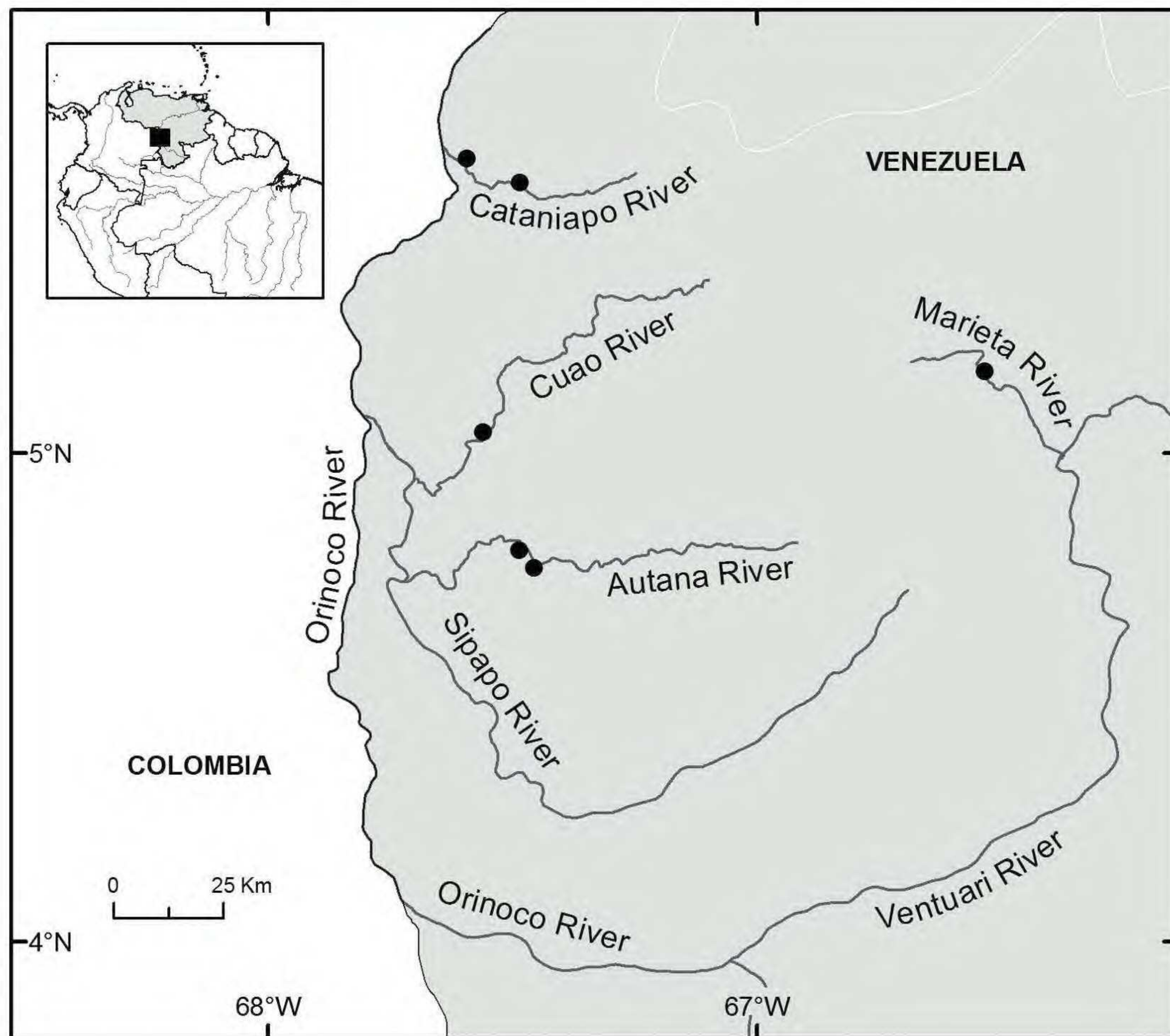


Figure 2. Region of northwestern South America (see inset map) emphasizing the northwestern part of the state of Amazonas, Venezuela. Only principal rivers are noted. Locations from which *Autana andersonii* has been collected (Autana, Cataniapo, Cuao, and Marieta Rivers) are indicated with solid circles.

Jan. 1949, *Maguire & Politi 28400* (NY); Puerto Ayacucho, Río Cataniapo, ca. 15 km E of main rd., 5.5548°N, 67.4856°W, 9 Jan. 2006, *Philbrick, Novelo & Lasso 5878* (CAR, MO, VEN, WCSU); Puerto Ayacucho, Río Cataniapo, at bridge along rd. to Samariapo, 5.6034°N, 67.5937°W, 9 Jan. 2006, *Philbrick, Novelo & Lasso 5875* (CAR, MO, VEN, WCSU); Canyo Marieta, ca. 1 hr. by boat upstream of confluence with Río Ventuari, 5.1687°N, 66.5334°W, 8 Mar. 2009, *Philbrick, Fort & Perrez 6318* (VEN, WCSU).

Acknowledgments. We thank Albino Luna for drawing Figure 1 and Arturo Mora Olivo for providing the Spanish abstract. Fieldwork for this study could not have been conducted without the invaluable help of Carlos Lasso and Arnaldo Perrez, Fundación La Salle de Ciencias Naturales, Caracas. Their help is greatly appreciated. This study was supported by a National Science Foundation Grant DEB-0444589 and Connecticut State University–American Associ-

←
—G. One acute tepal. —H. Three mature capsules projecting from margins of flattened stem. —I. Mature indehiscent capsule and upper portion of pedicel. Note swollen pedicel apex, narrowed region between pedicel apex and capsule base (arrow), and inverted teardrop-shaped holes near pedicel apex. Holes occur where stamen filaments had attached. —J. Mature dehiscent capsule and upper portion of pedicel. Note swollen pedicel apex, the distinctive/characteristic inverted, teardrop-shaped holes, and two persistent capsule valves. —K. Portion of prostrate stem with one flower projecting from a pocket located between two leaf bases. Note dark lines that span the flattened stem where two leaf bases meet. A, C, H–K are based on the holotype *Philbrick et al. 5862* (VEN); B from *Philbrick et al. 5867* (WCSU); D–G from *Philbrick et al. 5875* (WCSU).

ation of University Professors (AAUP) research grants to C.T.P.

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